REMARKS

By the present amendment and response, independent claims 1 and 26 and dependent claim 4 have been amended to overcome the Examiner's objections. Claims 3, 10, 11, 30, 38, and 39 have been canceled. Thus, claims 1-2, 4-9, 17-22, and 26-37 are pending in the present application. Reconsideration and allowance of pending claims 1-2, 4-9, 17-22, and 26-37 in view of the following remarks are requested.

The Examiner has objected to the drawings under 37 CFR 1.83(a) because they fail to show the step of removing region 22B from the surface of epitaxial layer 13 as described in the specification. Applicant has amended Figures 3-14 by removing regions 22A and 22B from Figures 3-5 and region 22B from Figures 6-14 as noted on the amended drawings submitted herewith to overcome the Examiner's objections.

The Examiner has further objected to the drawings because the Specification does not provide a description for a nitride spacer (i.e. 111A) comprised of two layers. Applicant has amended Figure 11 as noted on the amended drawing submitted herewith to overcome the Examiner's objection.

The Examiner has further objected to the drawings because it is unclear whether the screen oxide is removed or not after the polysilicon is patterned to form emitter electrode 121 as shown in Figure 12. Applicant respectfully submits that emitter electrode 121 is formed through a series of standard process steps. See, for example, page 7, lines 23-24 of the patent application. Applicant further respectfully submits that when the doped polysilicon layer is patterned and etched to form emitter electrode 121,

the screen oxide layer, which had been deposited on the doped polysilicon layer, would have to be etched prior to etching of the doped polysilicon layer. As such, the screen oxide layer is etched by implication when the doped polysilicon layer situated underneath the screen oxide layer is etched.

The Examiner has further objected to the drawings as failing to comply with 37 CFR 1.84(p)(5) because they include the following reference sign(s) not mentioned in the description: the reference sign "153" in Figures 15 and 16. Applicant has amended Figures 15 and 16 by deleting the reference sign "153" as noted on the amended drawings submitted herewith to overcome the Examiner's objections.

The Examiner has further objected to the drawings as failing to comply with 37 CFR 1.84(p)(5) because they do not include reference sign "162" mentioned in the description. Applicant has amended Figure 16 to include reference sign "162" as noted on the amended drawing submitter herewith to overcome the Examiner's objection.

The Examiner has rejected claims 10-11 and 38-39 under 35 USC 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which Applicant regards as the invention. In response, Applicant has canceled claims 10-11 and 38-39.

The Examiner has further rejected claims 1-11, 17, 19-20, 26-27, and 38-39 under 35 USC 102(b) as being anticipated by Japanese patent number JP 4-177770 A to Hisao Sasaki ("Sasaki"). For the reasons discussed below, Applicant respectfully submits that

the present invention, as defined by amended independent claims 1 and 26 and independent claims 9 and 35, is patentably distinguishable over Sasaki.

The present invention, as defined by amended independent claim 1, teaches a method of forming a varactor device on a semiconductor substrate comprising steps of providing a semiconductor substrate having a first conductivity type, providing an isolation structure on the semiconductor substrate, where the isolation structure defines an implant region, selecting a first peak dopant concentration and a first implant energy such that at least one of capacitance, leakage current, and tuning range of the varactor device is optimized. The method of the present invention, as defined by amended independent claim 1, further teaches forming a first implant in the implant region using the first implant energy, where the first implant has a first peak dopant concentration and a second conductivity type, and where the first implant extends into the implant region a first distance, and forming a second implant in the implant region using a second implant energy, where the second implant has a second peak dopant concentration and the second conductivity type, where the second implant extends into the implant region a second distance, and where the second distance is greater than the first distance. By appropriately selecting the first peak dopant concentration and first implant energy of the first implant, the present invention advantageously achieves a varactor device having at least an optimized capacitance, leakage current, or tuning range. Furthermore, as disclosed in the patent application, by appropriately selecting the second peak dopant concentration and second implant energy of the second implant, the present invention

achieves a varactor having a minimized base resistance, which advantageously results in the varactor having an optimized quality factor ("Q"). Thus, by appropriately choosing the first and second peak dopant concentrations and first and second implant energies of first and second implants, respectively, the present invention advantageously achieves a double-implant varactor that can be selectively optimized to match the specific requirements of a particular application. For example, all of the parameters, i.e. capacitance, leakage current, tuning range, and base resistance, of the present invention's varactor can be optimized by choosing the appropriate the first and second peak dopant concentrations and first and second implant energies of first and second implants, respectively. By way of further example, the above parameters of present invention's varactor could be selected for optimal leakage current and tuning range and a non-optimal base resistance.

In contrast, Sasaki does not teach, disclose, or suggest a varactor formed by a first and a second implant, where a first peak dopant concentration and first implant energy of the first implant is selected such that at least one of capacitance, leakage current, or tuning range is optimized, and where the first implant is shallower than the second implant. Sasaki specifically discloses a varactor formed by shallowly forming high concentration p-type diffusion layer 5 in a part of the surface of p-type diffusion layer 4 to reduce the series resistance of an element. See, for example, the abstract, constitution, and Figures 1 and 4 of Sasaki. In Sasaki, the high concentration p-type diffusion layer, i.e. high concentration p-type diffusion layer 5, is formed by shallowly implanting a high

concentration of boron ions in part of an already existing p-type diffusion layer, i.e. p-type diffusion layer 4. See, for example, the constitution of Sasaki. Thus, in Sasaki, an implant comprising a high concentration of p-type dopant, e.g. boron ions, is formed in a p-type diffusion layer to lower the series resistance, i.e. the contact resistance, of an electrode. For the foregoing reasons, Applicant respectfully submits that the present invention, as defined by amended independent claim 1, is not suggested, disclosed, or taught by Sasaki.

The present invention, as defined by independent claim 9, is a method of forming a varactor on a semiconductor substrate that comprises, among other things, forming a first implant having a first peak dopant concentration using a first implant energy, and forming a second implant having a second peak dopant concentration using a second implant energy, where the first peak dopant concentration and first implant energy are selected such that at least one of capacitance, leakage current, and tuning range of the varactor are optimized, and where the second peak dopant concentration and second implant energy are selected with relation to the first peak dopant concentration and first implant energy such that the base resistance of the varactor is minimized. Further, the present invention, as defined by amended independent claim 26, defines a method of forming a varactor comprising, among other things, selecting a first peak dopant concentration and first implant energy such that at least one of capacitance, leakage current, and tuning range of the varactor is optimized. Moreover, the present invention, as defined by independent claim 35, defines a method of forming a varactor device by forming a first and second

implant that also includes a limitation of selecting a first peak dopant concentration and first implant energy of the first implant such that at least one of capacitance, leakage current, and tuning range of the varactor device are optimized. As such, and based on the foregoing reasons, independent claims 9 and 35 and amended independent claim 26 are patentably distinguishable over Sasaki. Thus, claims 2 and 4-8 depending from amended independent claim 1, claims 17, 19-20, and 22 depending from independent claim 9, claims 27 and 29 depending from amended independent claim 26, and claim 36 depending from independent claim 35 are also patentably distinguishable over Sasaki.

The Examiner has further rejected claims 1-4, 6-7, 9-11, 17-22, 26-31, and 33-39 under 35 USC 103(a) as being unpatentable over U.S. patent number 5,405,790 to Rahin et al. ("Rahin") in view of U.S. patent number 5,024,955 to Takeshi Kasahara ("Kasahara"). For the reasons discussed below, Applicant respectfully submits that the present invention, as defined by amended independent claims 1 and 26 and independent claims 9 and 35, is patentably distinguishable over Rahin and Kasahara, either singly or in combination.

In contrast to the present invention as defined by amended independent claims 1 and 26 and independent claims 9 and 35, Rahin specifically discloses a varactor formed in varactor region 13 by implanting lightly doped region 103 with an impurity material of P conductivity type to form anode region 109. See, for example, column 8, lines 53-65 and Figure 22 of Rahin. Thus, in Rahin, the varactor formed in varactor region 13 is formed using only a single implant. For the foregoing reasons, Applicant respectfully submits

that the present invention, as defined by amended independent claims 1 and 26 and independent claims 9 and 35, is not suggested, disclosed, or taught by Rahin.

In contrast to the present invention as defined by amended independent claims 1 and 26 and independent claims 9 and 35, Kasahari specifically discloses a method of making a variable capacitance diode element comprising, among other things, forming diffusion layer 13 by implanting a P-type impurity element such as boron into diffusion layer 11 through opening portion 12 under such conditions as an accelerating voltage of 100 KeV and dosage of (5 to 8) x 10^{13} cm^{-2}. See, for example, column 4, lines 32-37 and Figure 4(c) of Kasahari. In Kasahari, P++ type diffusion layer 15 is formed by forming opening portion 14 to expose diffusion layer 11 and implanting P-type impurity element such as boron through opening portion 14 under such conditions as an accelerating voltage of 20 KeV and dosage of (5 to 8) x 10^{13} cm^{-2}. See, for example, column 4, lines 42-49 and Figure 4(d) of Kasahari. In Kasahari, the quality factor ("Q") of the variable capacitance diode element is enhanced by reducing the thickness of epitaxial layer 2, in which P++ type diffusion layer 15 and diffusion layer 11 are formed, by making P++ type diffusion layer 15 very thin without increasing the break-down voltage of the element. See, for example, column 6, lines 9-16 and Figure 4(d) of Kasahari. For the foregoing reasons, Applicant respectfully submits that the present invention, as defined by amended independent claims 1 and 26 and independent claims 9 and 35, is not suggested, disclosed, or taught by Kasahari. As such, and based on the foregoing reasons, amended independent claims 1 and 26 and independent claims 9 and 35 are patentably

distinguishable over Rahim and Kasahari, either singly or in combination. Thus, claims 1-2, 4, and 6-7 depending from amended independent claim 1, claims 17-22 depending from independent claim 9, claims 27-29, 31, and 33-34 depending from amended independent claim 26, and claims 36-37 depending from independent claim 35 are also patentably distinguishable over Rahim and Kasahari.

The Examiner has further rejected claims 5, 8, and 32 under 35 USC 103(a) as being unpatentable over Rahin in view of Kasahara, and further in view of U.S. patent number 5,691,546 to Masakaza Morishita ("Morishita"). As discussed above, amended independent claims 1 and 26 are patentably distinguishable over Rahin and Kasahara and, as such, claims 5 and 8 depending from amended independent claim 1 and claim 32 depending from amended independent claim 26 are, a fortiori, also patentably distinguishable over Rahin and Kasahara.

Based on the foregoing reasons, the present invention, as defined by amended independent claims 1 and 26 and independent claims 9 and 35, and claims depending therefrom, is patentably distinguishable over the art cited by the Examiner. Thus, claims 1-2, 4-9, 17-22, and 26-37 pending in the present application are patentably distinguishable over the art cited by the Examiner. As such, and for all the foregoing reasons, an early allowance of claims 1-2, 4-9, 17-22, and 26-37 pending in the present application is respectfully requested.

Respectfully Submitted,
FARJAMI & FARJAMI LLP

Michael Farjami, Esq.
Reg. No. 38, 135

Date: 7/29/02

Michael Farjami, Esq.
FARJAMI & FARJAMI LLP
16148 Sand Canyon
Irvine, California 92618
Telephone: (949) 784-4600
Facsimile: (949) 784-4601

I hereby certify that this correspondence is being deposited with the United States Postal Service as first class mail in an envelope addressed: Commissioner of Patents and Trademarks; Washington, D.C. 20231

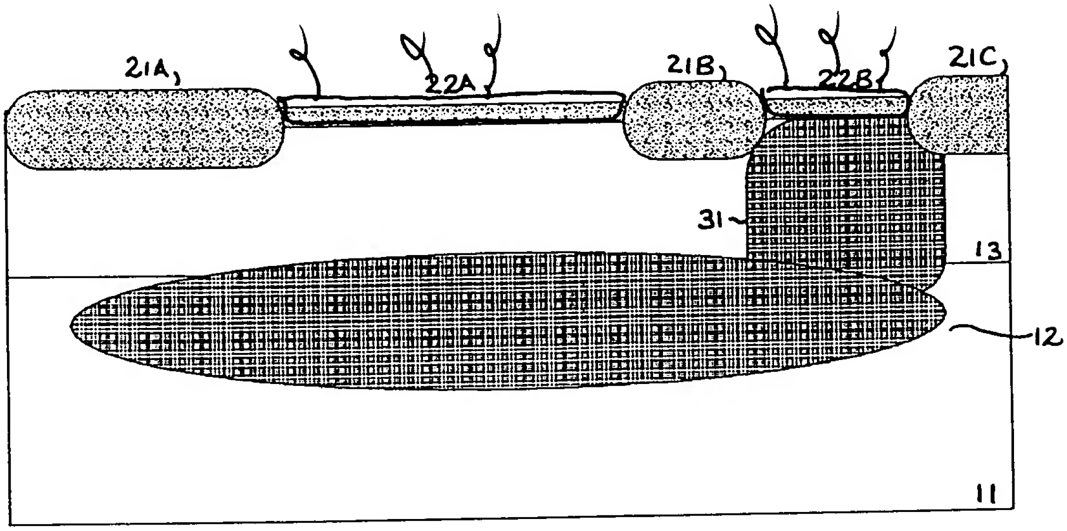
Date of Deposit: 7-29-02

Lori Llave
Name of Person Mailing Paper and/or Fee

7-29-02
Signature Date

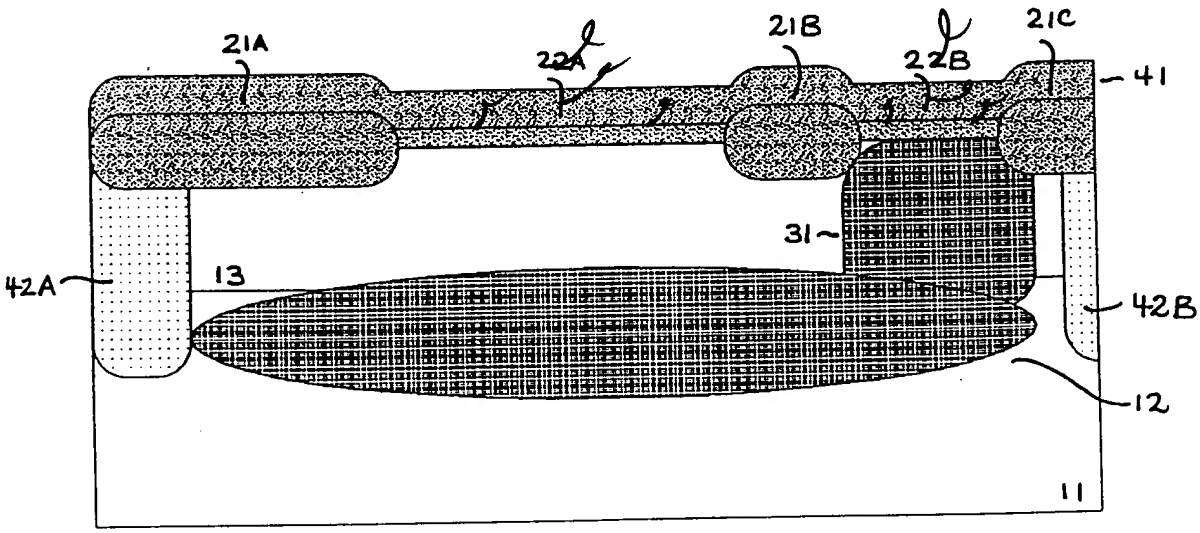
Amended

FIG. 3



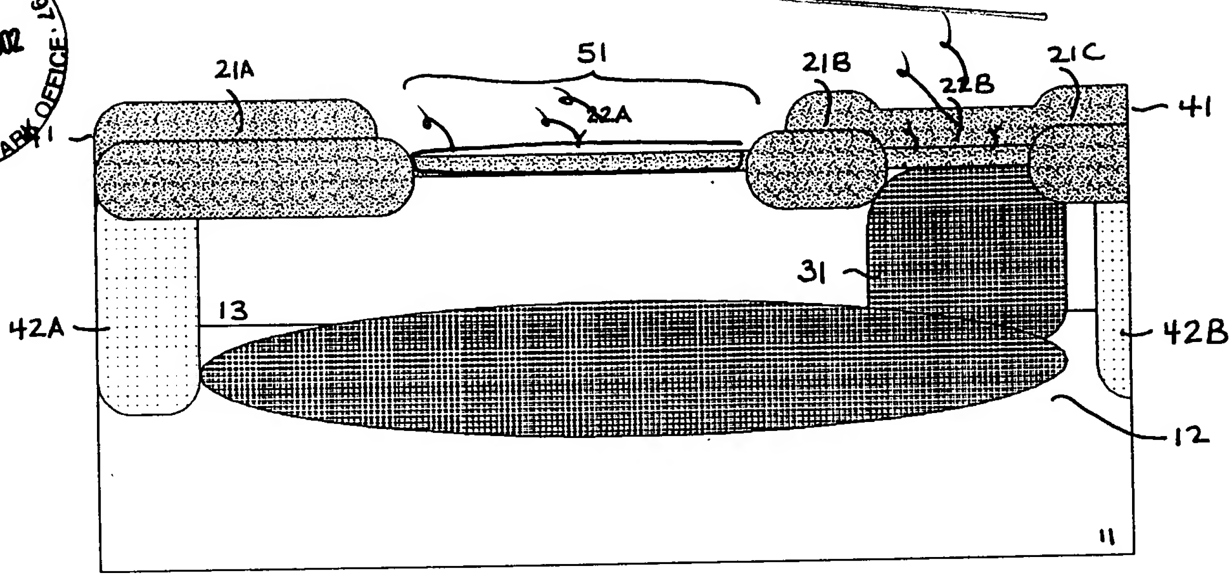
Amended

FIG. 4



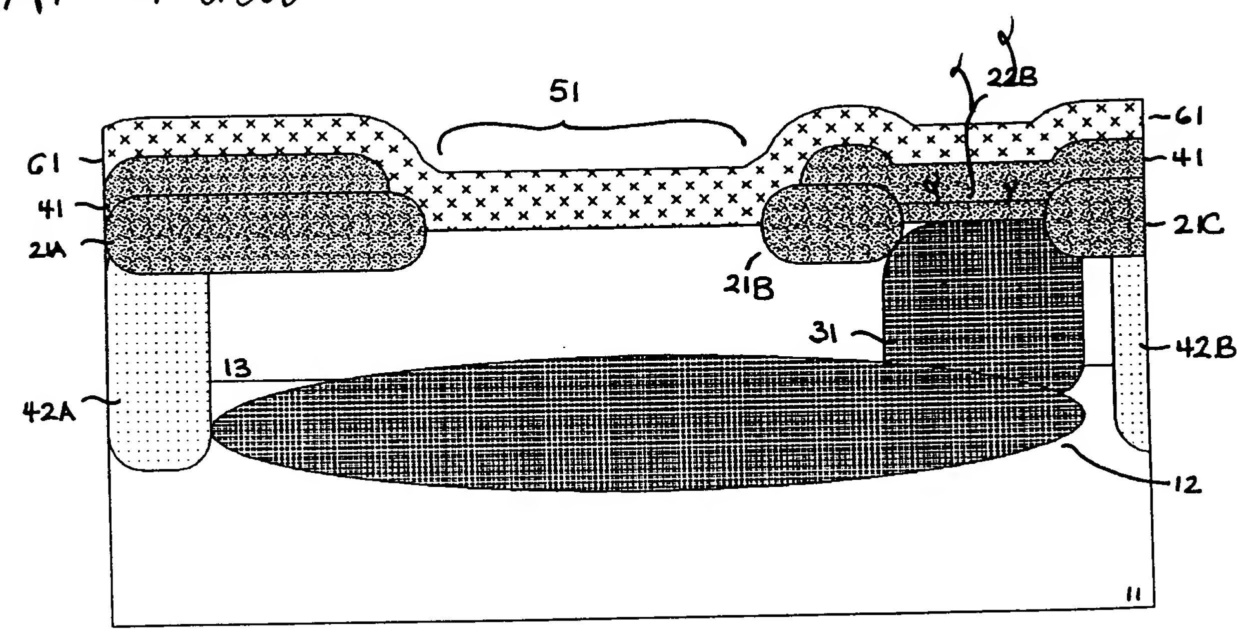
Amended

FIG. 5



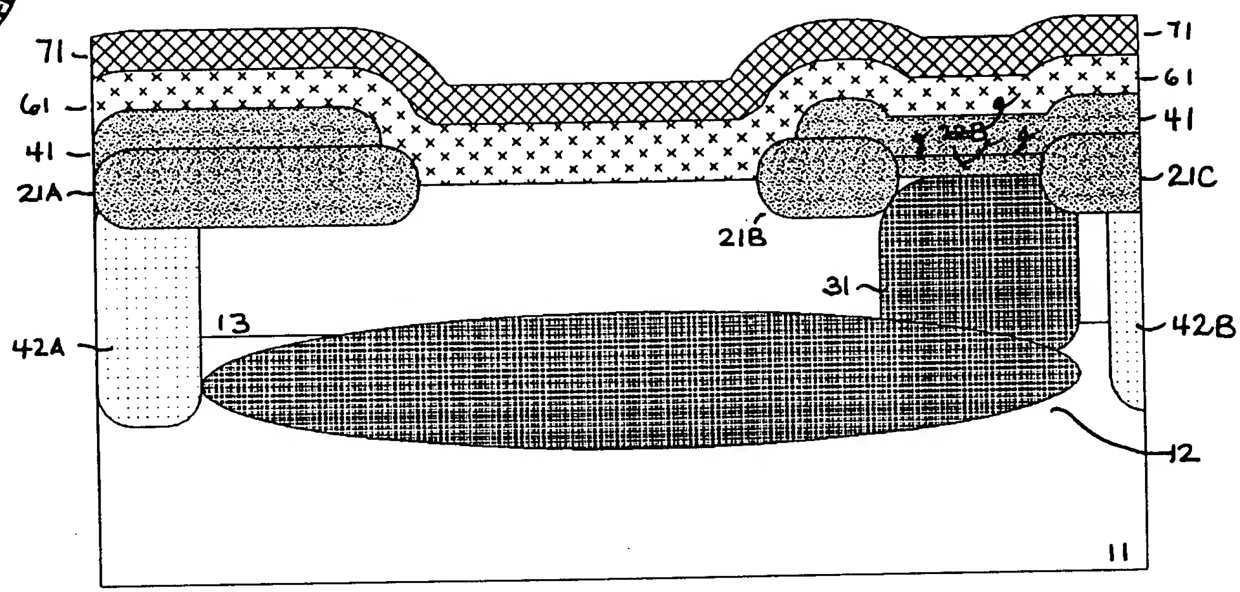
Amended

FIG. 6



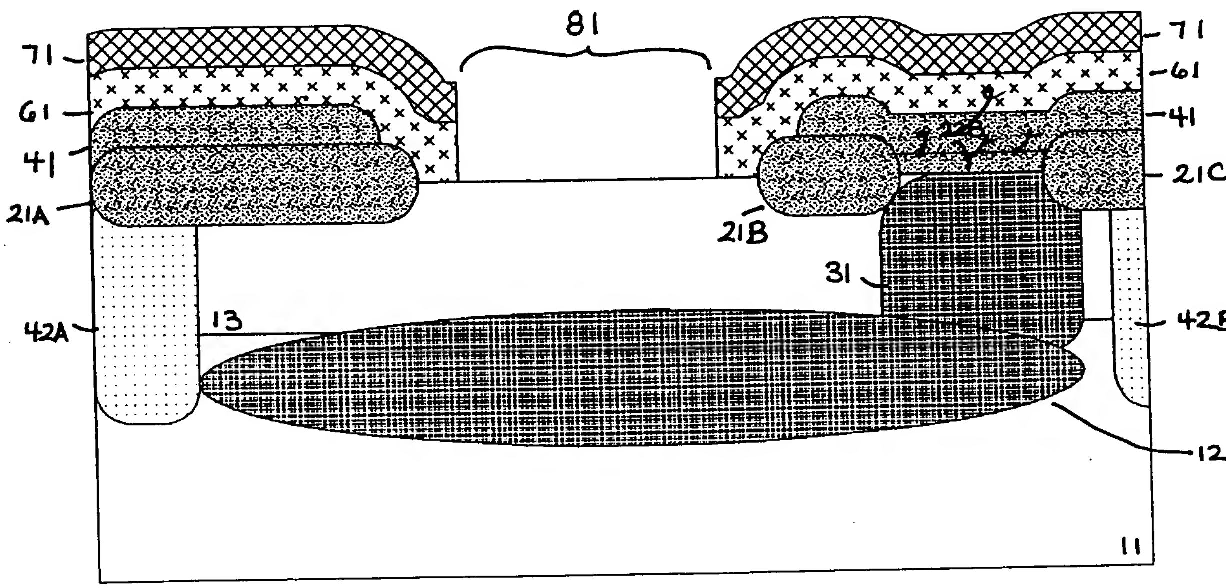
Amended

FIG. 7



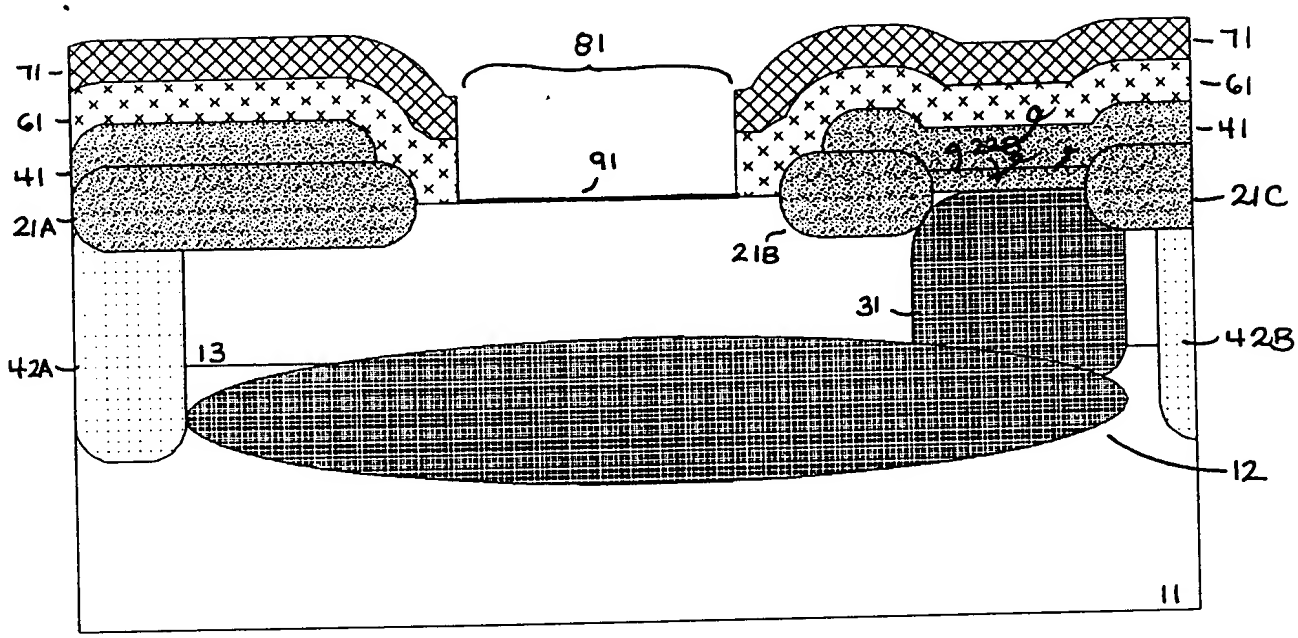
Amended

FIG. 8



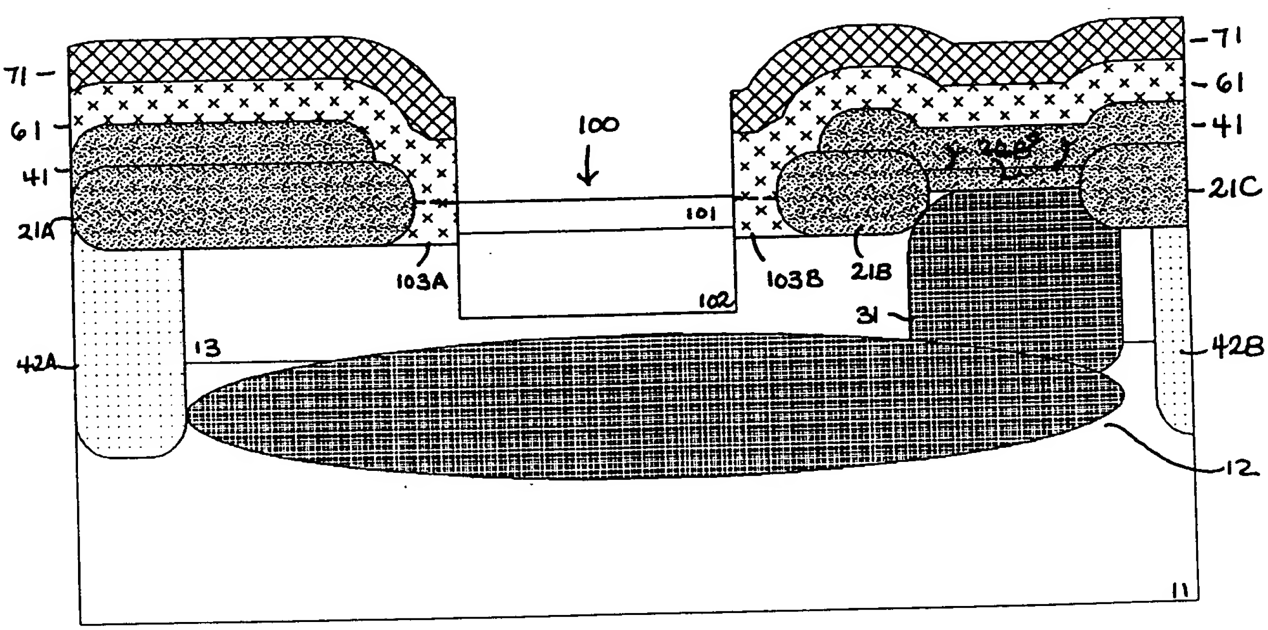
Amended

FIG. 9



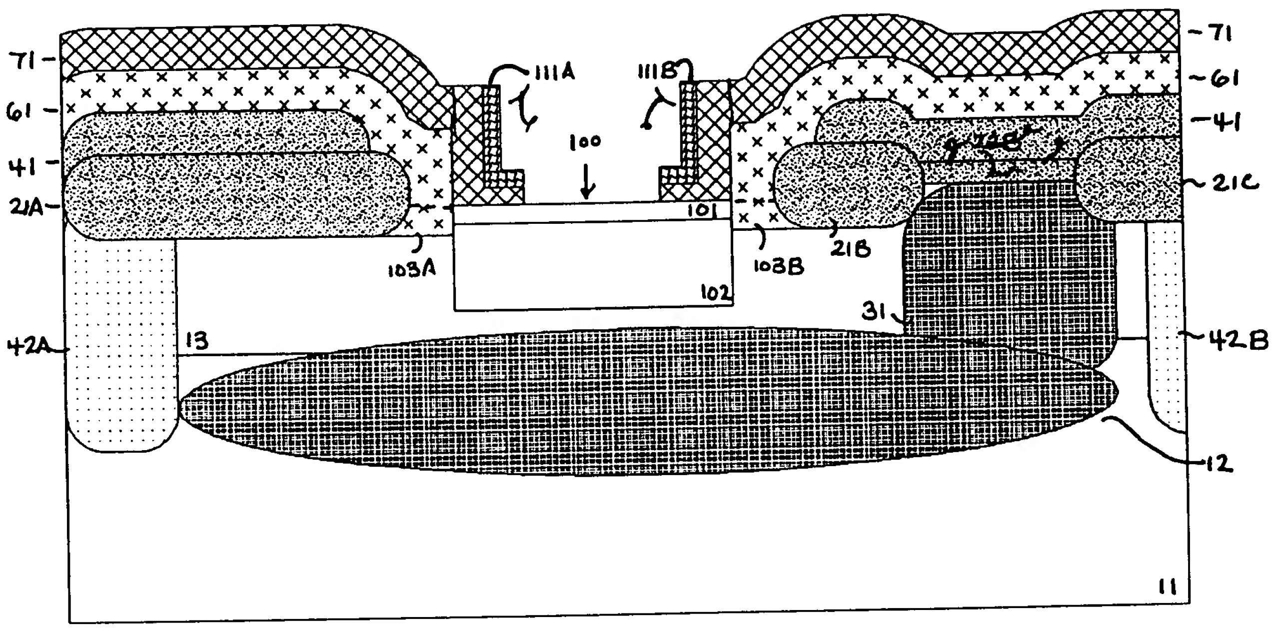
Amended

FIG. 10



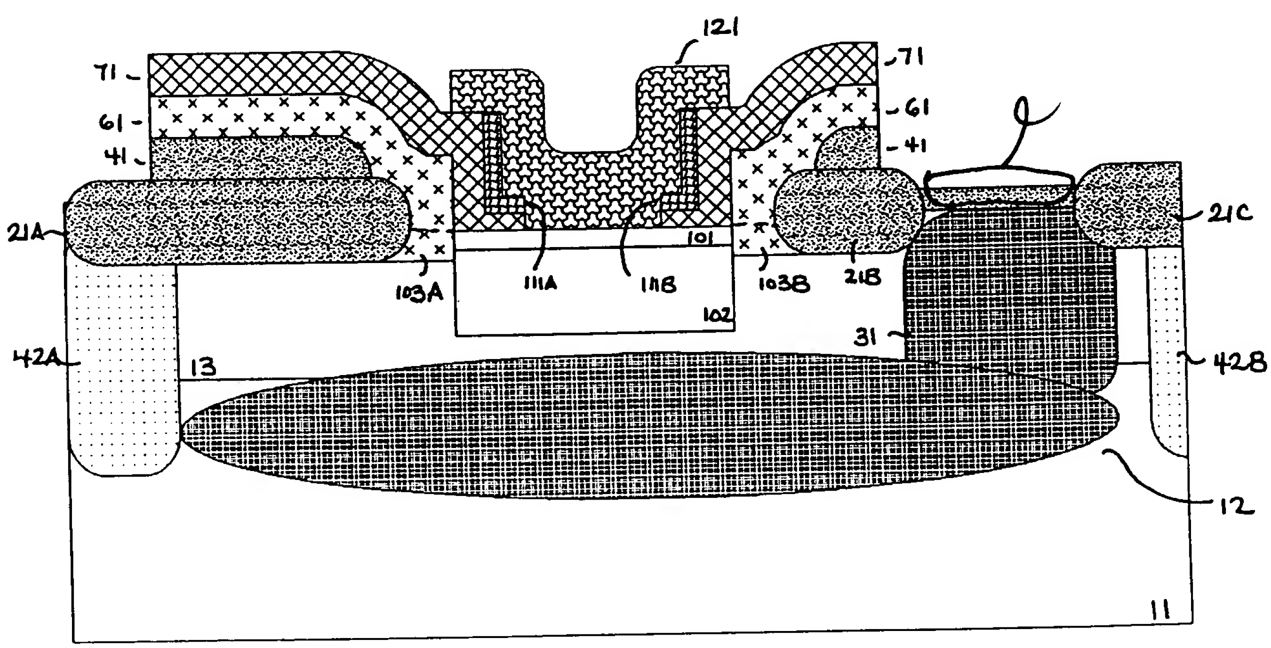
Amended

FIG. 11



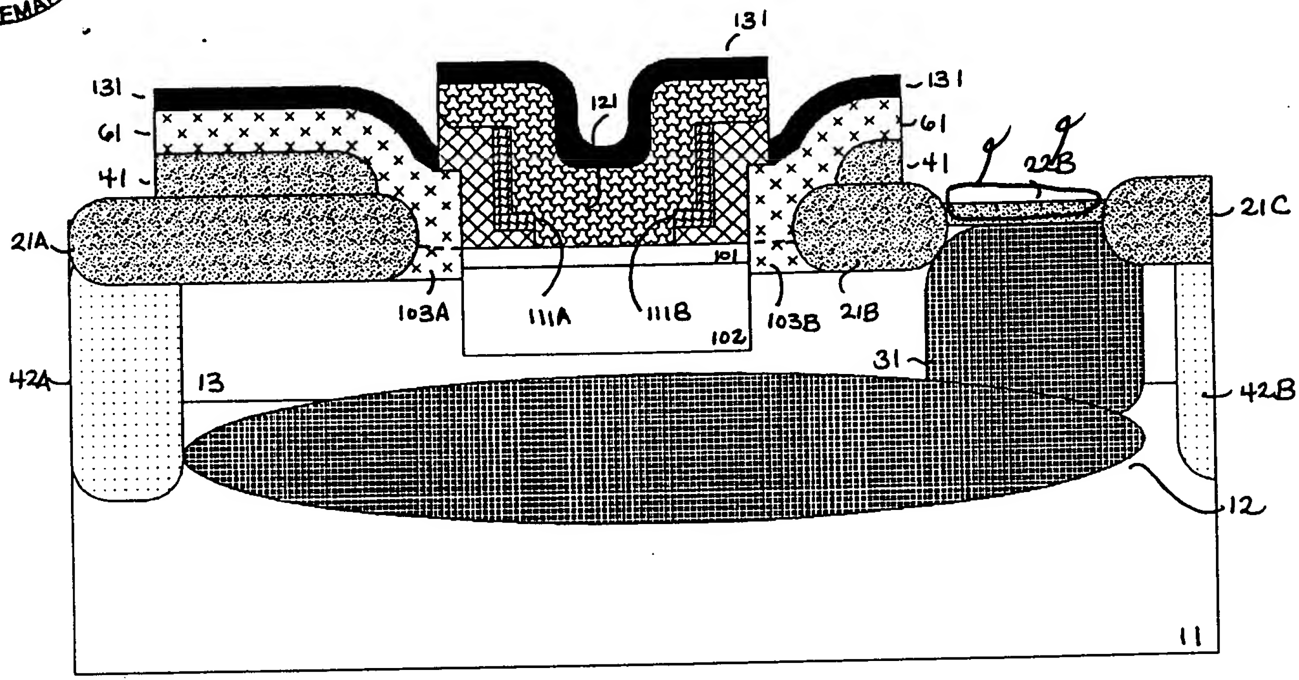
Amended

FIG. 12



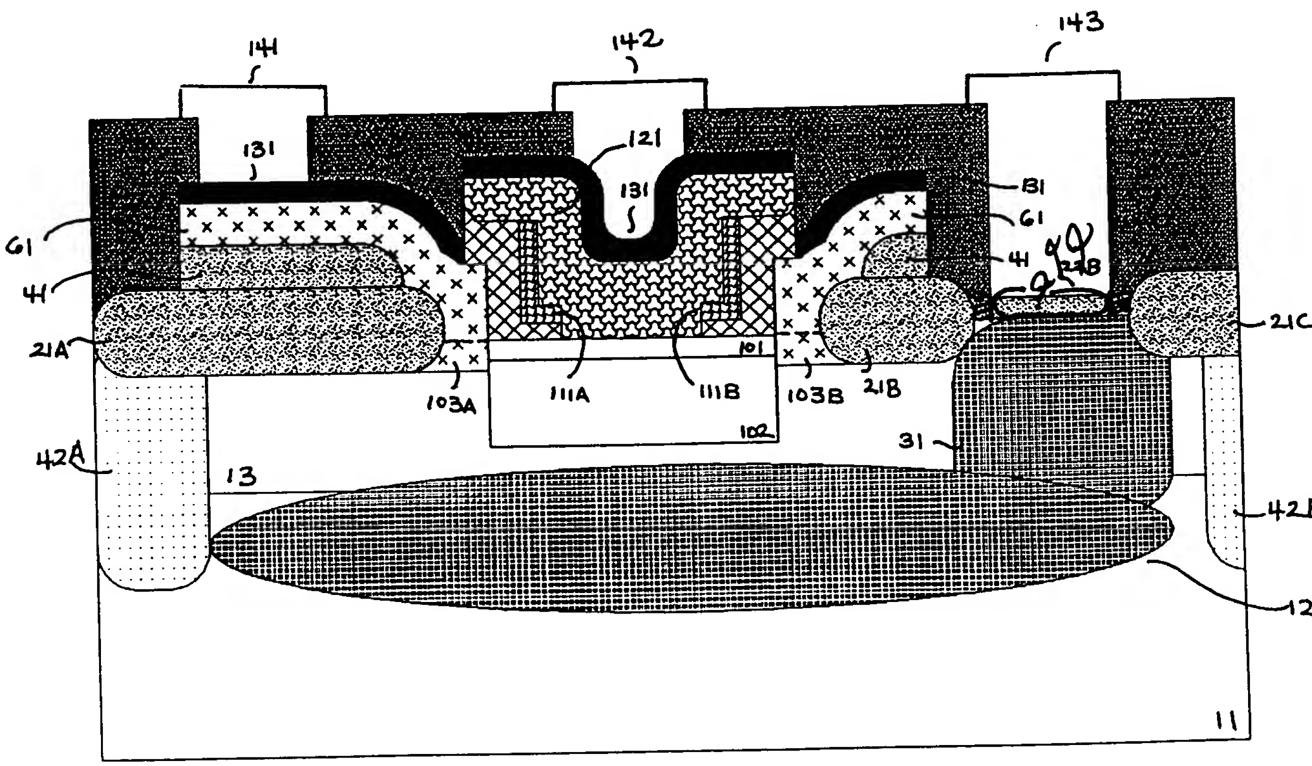
Amended

FIG. 13



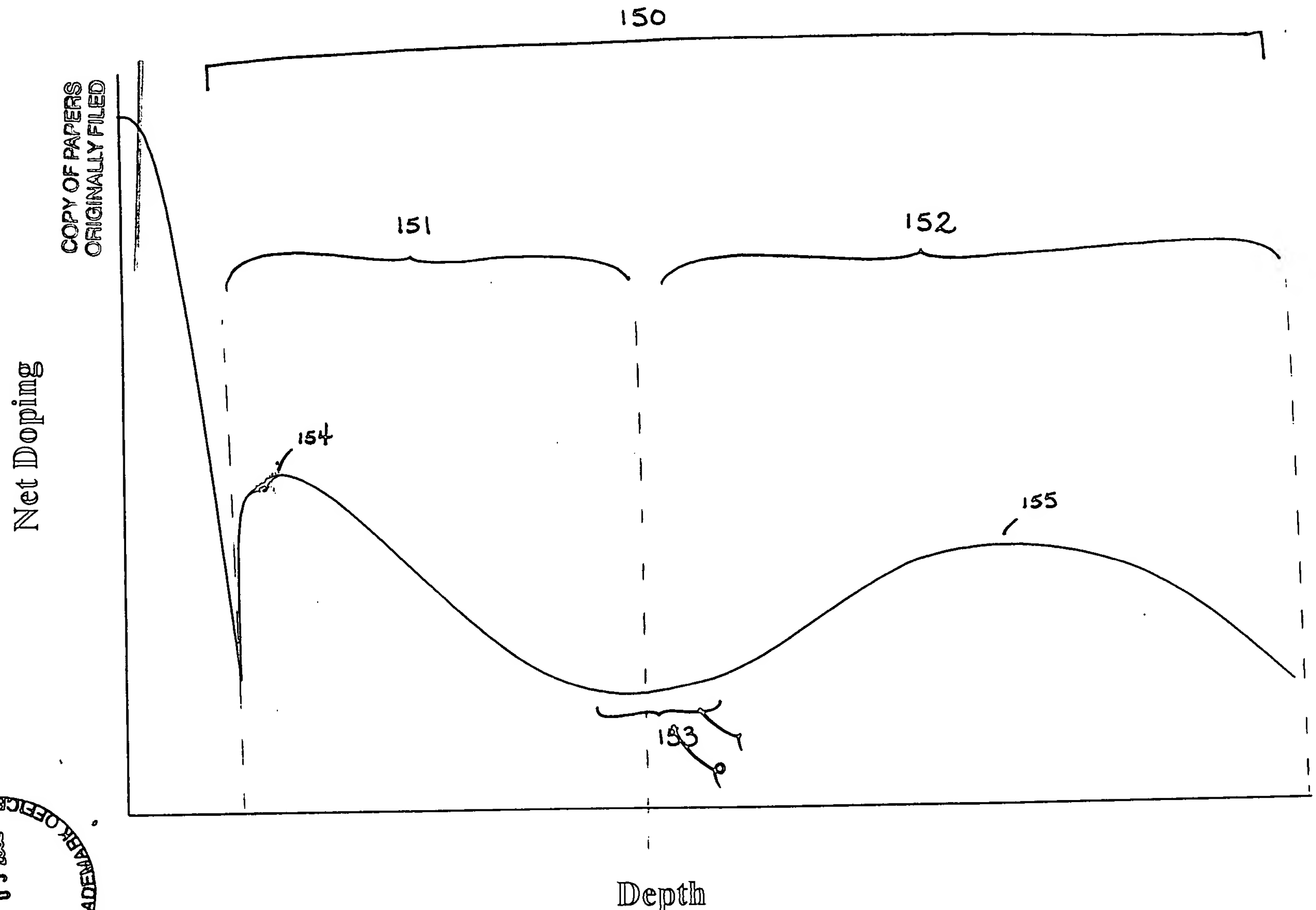
Amended

FIG. 14



Amended

FIG. 15



Amended

FIG. 16